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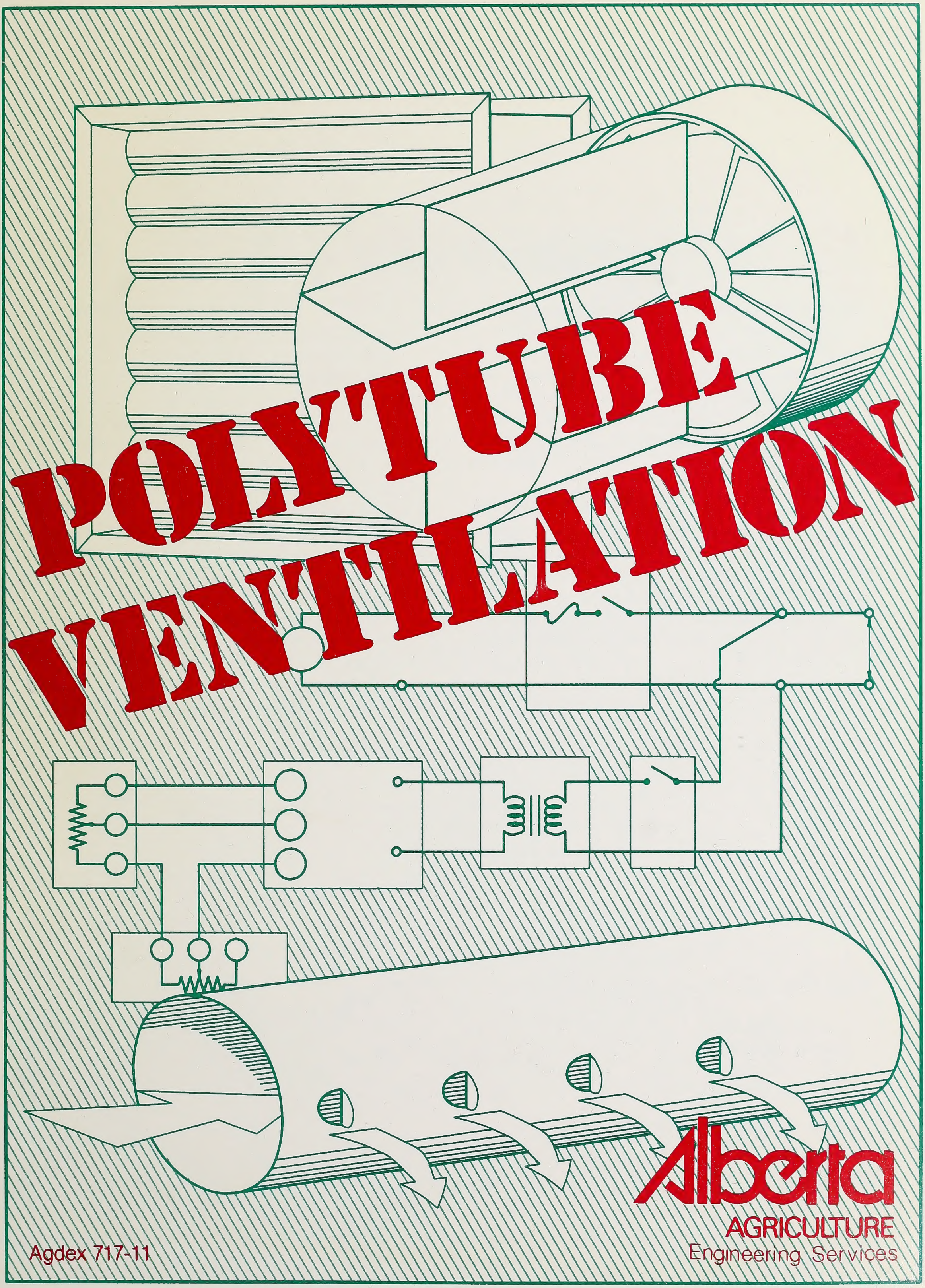
POLYTUBE VENTILATION



Agdex 717-11

Alberta
AGRICULTURE
Engineering Services

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Poly-Tube Ventilation

Introduction

Poly-tube ventilation is a positive pressure, air blending system that mixes a controlled and variable amount of fresh air with recirculated air before distributing it evenly throughout the barn. (Figure 1) An air blending system like this works effectively in most livestock barns, however it is particularly applicable to barns that do not ventilate well by traditional exhaust fans and air inlets. It is also particularly effective in providing even air distribution in large barns with relatively few livestock which require a precisely controlled low rate.

In order for an exhaust fan system to work well, the building must be nearly air-tight so the exhaust fan will draw in ventilation air through the designated air inlet. Otherwise, air enters through open doors or feed rooms where it is less effective and results in undesirable air distribution.

Barns for dairy and beef cattle, sheep housing and calving or lambing barns are not tightly built, and are often designed and operated with open doors and/or attached feeding areas. Poly-tube ventilation is probably the only effective type of system for these structures. Other applications are riding arenas, show barns and horse housing.

Air Mixing Principles

The main component of the positive pressure ventilation system is the air blending area or mixing chamber. Two air streams enter the chamber - outside air and recirculated barn air. The fans create the suction that draws this air into the mixing room. (Figure 2)

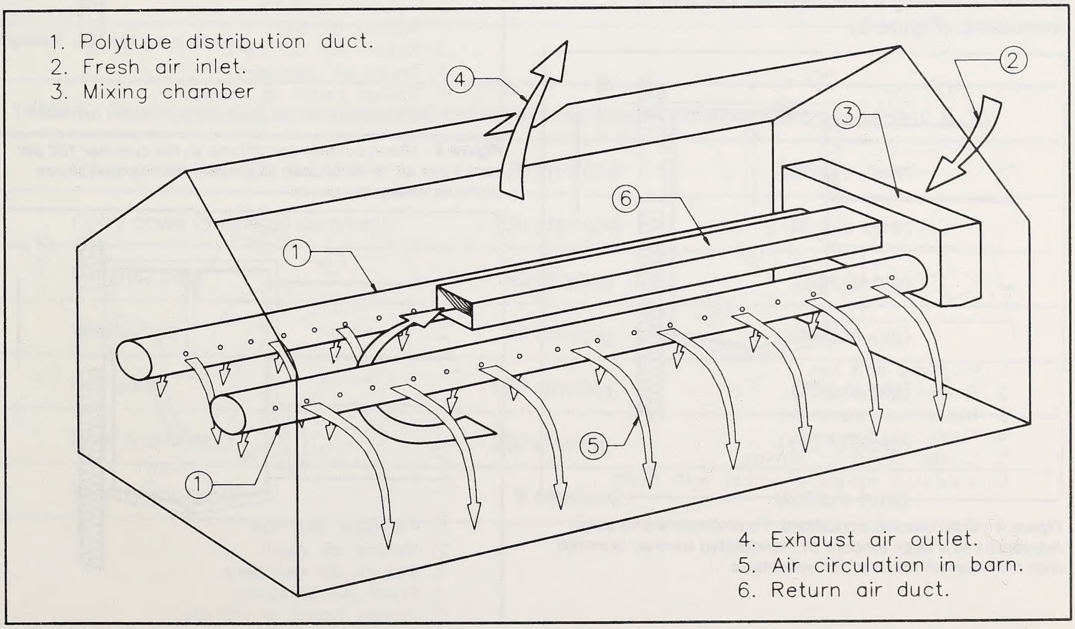

Figure 1 *- Positive pressure ventilation. Continuously running fans deliver fresh air to all parts of the barn through poly-tubes. Temperature is controlled by mixing fresh and recirculated air. Stale air exhausts by convection through a chimney.*

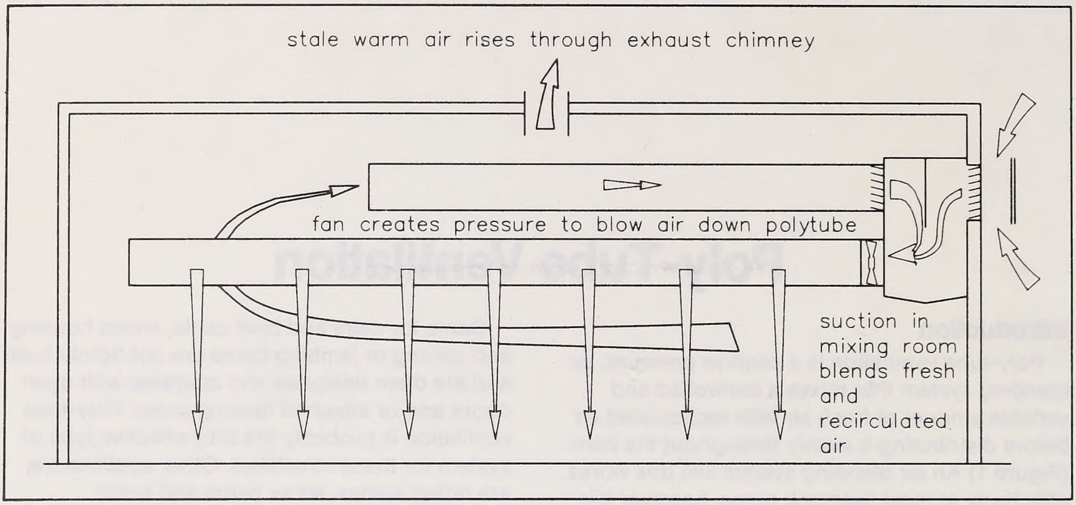
stale warm air rises through exhaust chimney
fan creates pressure to blow air down polytube
suction in mixing room blends fresh and recirculated air

Figure 2 - *Air mixing room. Suction created by continuously running fans draws fresh air and recirculated air into the mixing room.*

The temperature in the barn is controlled by blending fresh and recirculated air. As the outside temperature decreases, the amount of recirculated air is increased and the amount of fresh air is decreased. (Figure 3)

As the outside temperature increases, more fresh air is introduced and less recirculated air is used. (Figure 4)

Moisture in the barn is controlled by maintaining a minimum supply of fresh air to the mixing room. If the barn is too wet, the minimum pre-set opening of the fresh air damper is increased. (Figure 5)

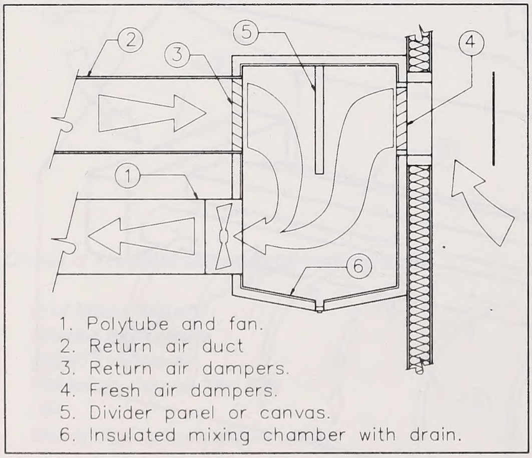

Figure 3 - *Cold outside conditions. To maintain warm barn temperatures a large amount of recirculated barn air is mixed with the fresh air required for ventilation.*

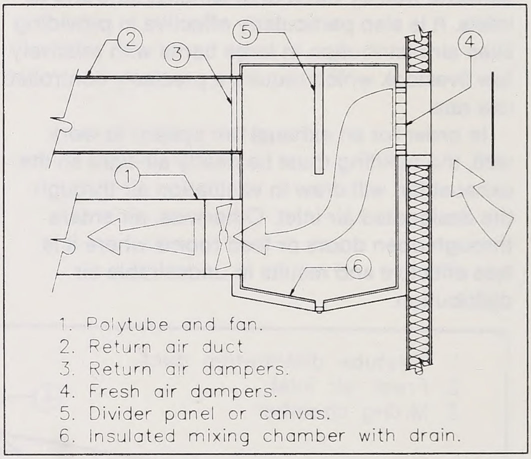

Figure 4 - *Warm outside conditions. In the summer 100 per cent fresh air is introduced to prevent barn temperatures from becoming too warm.*

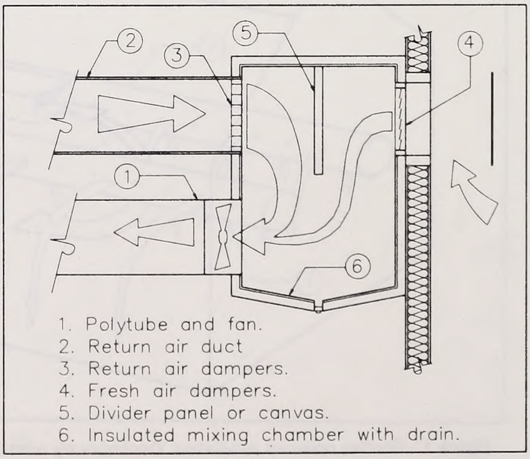

Figure 5 - *Minimum winter ventilation. A minimum supply of fresh air is needed at all times. Cold winter air is very dry and can absorb all the moisture produced by the animals.*

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How to Design a Positive Pressure System

A. Mixing Room or Preheat Hallway

The air mixing room is the main component of the ventilation system. This design uses a large room 4 feet (1200 mm) wide, 6 to 8 feet (1800-2400 mm) high and a length depending on the building size and shape. The large size allows easy access to the equipment and allows the air to mix more thoroughly before it enters the barn.

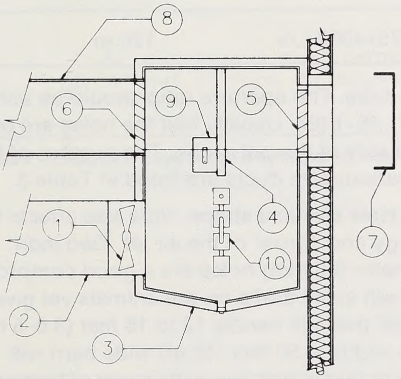
The room should be insulated preferably with a rigid insulation such as rigid polystyrene. Line the interior with a water resistant material and caulk all the joints. Slope the floor towards a floor drain to allow easy removal of condensation. (Figure 6)

B. Fan Sizing

Choose the fan sizes based on the maximum ventilation required. For pigs this may be the summer ventilation rate. For dairy cows that are on pasture in the summer, the maximum ventilation may be the spring and fall ventilation rates. Suggested rates are listed in Table 1.

In a positive pressure system the fans run continuously. It is good practice to provide a separate electrical circuit and breaker for each fan.

An option is to use variable speed fans. Do not run variable speed fans at less than 50 per cent of maximum air capacity.



1. Duct circulation fan
2. Polytube distribution duct.
3. Insulated mixing chamber with drain.
4. Plywood or canvas divider to separate ⑤ from ⑥.
5. Fresh air damper
6. Return air damper.
7. Wind protection hood.
8. Recirculation duct.
9. Modulating damper motor.
10. Hot water heating coils, fin – tube type.

Figure 6 - Mixing room detail

Table 1 - Recommended ventilation rates, cubic feet per minute (cfm) or litres per second (L/s)

Dairy cows (outside in summer)	- 125 cfm/cow	(60 L/s-cow)
Dairy cows (inside all summer)	- 250 cfm/cow	(120 L/s-cow)
Finisher pigs	- 60 cfm/pig	(30 L/s-pig)
Weanlings	- 32 cfm/pig	(15 L/s-pig)
Dry sows	- 150 cfm/pig	(70 L/s-pig)
Sow and litter	- 250 cfm/pig	(120 L/s-pig)
Poultry (boilers)	- 5 cfm/bird	(2.5 L/s-bird)

Table 2 - Fan and poly-tube sizing

Duct diameter	Fan power	Air flow	Maximum length
12 in	1/6-1/4 hp	1000-1200 cfm	100 ft
18 in	1/4-1/3 hp	3000-3200 cfm	200 ft
24 in	1/3-1/2 hp	5000-5400 cfm	360 ft
30 in	1/2-3/4 hp	8000-8500 cfm	400 ft
300 mm	125-190 W	500-570 L/s	30 m
450 mm	190-250 W	1400-1500 L/s	60 m
600 mm	250-375 W	2350-2550 L/s	110 m
750 mm	375-560 W	3775-4000 L/s	120 m

C. Poly-Tube Design

A number of factors are important in poly-tube design to ensure even air distribution within the barn. Choices are made with respect to tube diameter, hole size and spacing.

1. Tube diameter and length. Size the tube equal to or larger than the fan diameter. Typical poly-tube and fan combinations are listed in Table 2.

2. Number of holes. Too many holes will prevent proper inflation of the poly-tube; too few holes will restrict the air flow and overload the fan. The number of holes is based on the aperture ratio, which is the ratio of the total area of discharge holes divided by the cross-sectional area of the poly-tube. The aperture ratio should be about 1.5 (1.25-1.85). Usually half the holes are on each side of the poly-tube. The number of holes for various size ducts are listed in Table 3.

Table 3 - Number of holes in poly-tubes

Duct diameter		Hole diameter			
(in)	(mm)	1 in	1.5 in	2 in	3 in
		(25 mm)	(38 mm)	(50 mm)	(75 mm)
12	300	300	220	96	24
18	450	490	220	120	54
24	600	860	380	220	96
30	750	1350	600	340	150

Hole calculation formula: number of holes = 1.5 (duct diameter)^2 / (hole diameter)^2

3. Hole size and shape. Hole size affects the energy and 'throw' of the air jet. Two inch diameter (50 mm) holes are a good compromise that will avoid drafts on the animals yet give a 'throw' that will handle 12 to 16 feet (3.6-5 m) of barn width. A 50 feet (15 m) wide barn will require two poly-tubes with a row of holes down each side of the poly-tube. The throw from each tube is 50/4 = 12 feet.

For younger animals use smaller holes to prevent drafts. For older animals or summer ventilation larger holes work well.

Air is often discharged in a downstream direction from the holes rather than perpendicular to the poly-tube. To counteract the downstream movement the holes may be cut in the shape of a 'D' (Figure 7). In most cases this is not significant or necessary unless short ducts are being installed in small rooms.

4. Hole spacing. For ducts over 150 feet space the holes equally. For shorter ducts with evenly spaced holes, most of the air will be discharged at the end furthest away from the fan. For even distribution follow these steps:

a) Calculate the average hole spacing.
b) Space the holes nearest to the fan at 0.75 times the average spacing.
c) Space the holes furthest away at 1.33 times the average spacing.
d) Along the duct, gradually vary the spacing between these two extremes. (Figure 8)

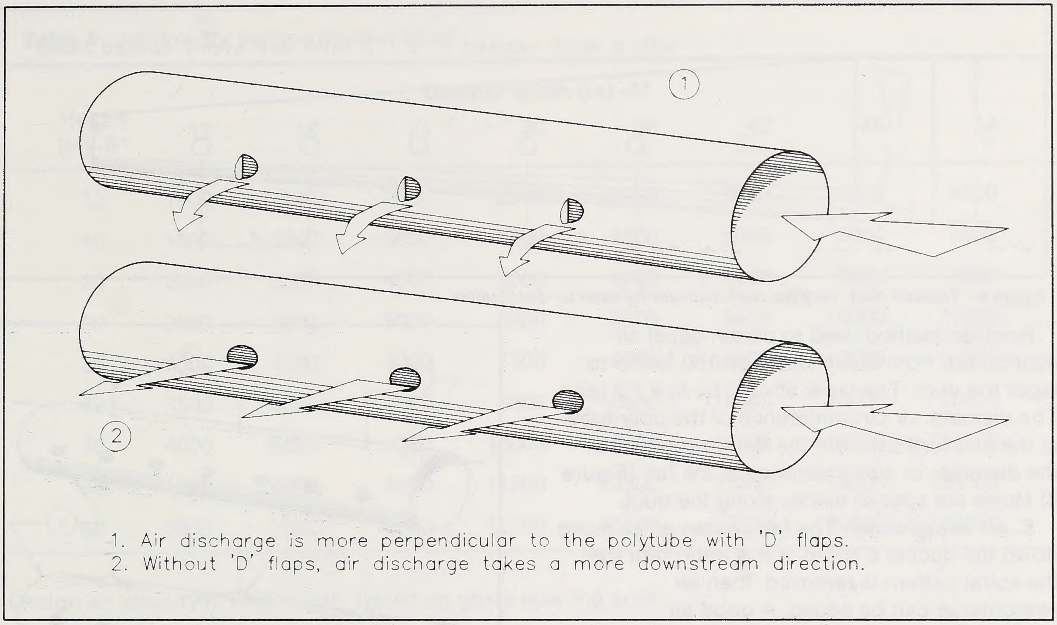

1
2
1. Air discharge is more perpendicular to the polytube with 'D' flaps.
2. Without 'D' flaps, air discharge takes a more downstream direction.

Figure 7 - *Effect of D-flaps on air discharge, for use in small rooms.*

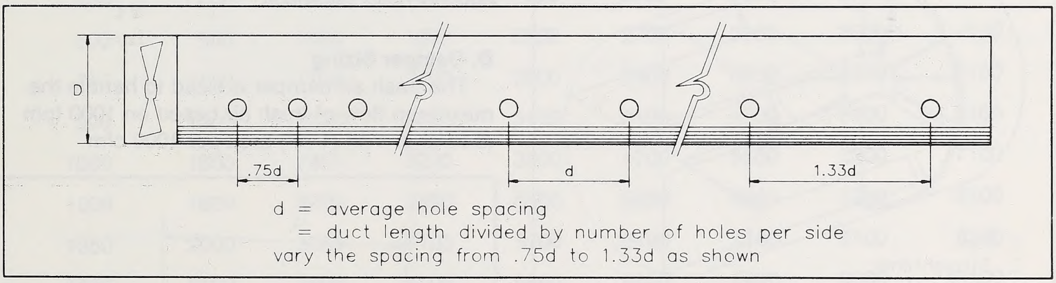

D
.75d
d
1.33d
d = average hole spacing
= duct length divided by number of holes per side
vary the spacing from .75d to 1.33d as shown

Figure 8 - *Hole spacing. Vary the hole spacing for even air distribution.*

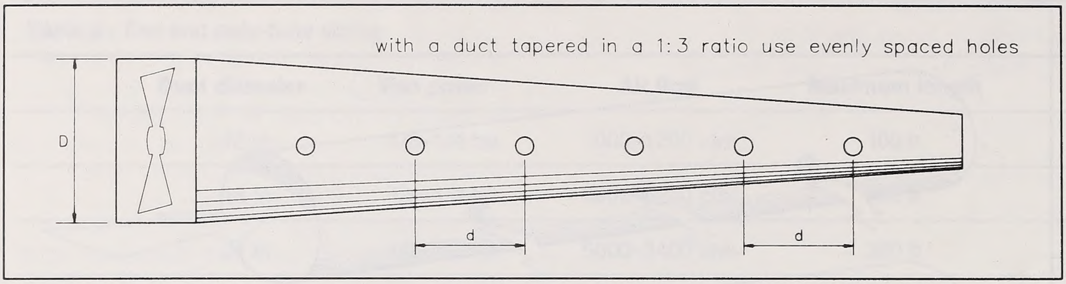


***Figure 9** - Tapered duct. Vary the duct diameter for even air distribution.*

Another method used to obtain equal air distribution from ducts less than 150 feet is to taper the duct. The taper should be in a 1:3 ratio. The diameter or circumference of the poly-tube at the end furthest from the fan is one-third of the diameter or circumference at the fan.(Figure 9) Holes are spaced evenly along the duct.

5. Air straightener. The fan causes air to move down the duct in a spiral. If it is important that the spiral pattern is removed, then air straightener can be added. A good air straightener has a length of two duct diameters and has four fins which are not joined at the centre. (Figure 10)

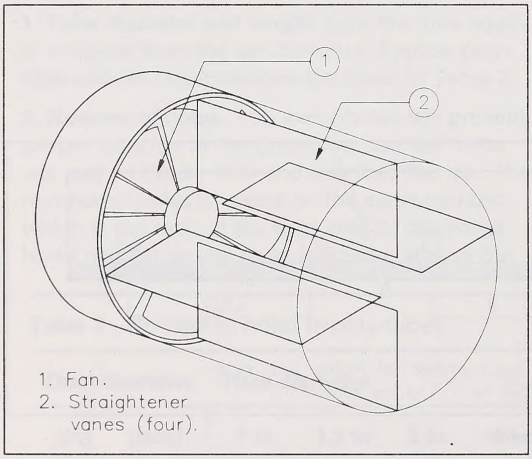


***Figure 10** - Air straightener. Effects of straightener on air discharge.*

6. Duct suspension. The poly-tube should be suspended from the top.Clips as shown in Figure 11 may be used. Another method is to string a light cable the full length of the poly-tube and fasten both ends to a good support. Wires may be attached through the poly-tube to the cable to provide additional support along the tube.

Poly-tubes are available in clear plastic with or without holes from various greenhouse suppliers and plastic manufacturers. Typical sizes available are 6, 12, 18, 24, and 30 inch diameters.

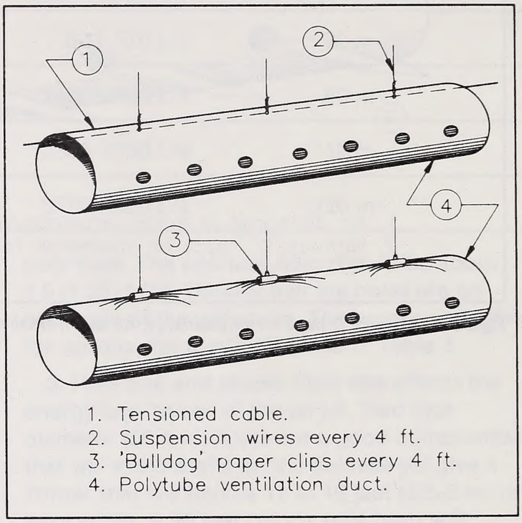

1
2
3
4
1. Tensioned cable.
2. Suspension wires every 4 ft.
3. 'Bulldog' paper clips every 4 ft.
4. Polytube ventilation duct.

***Figure 11** - Duct suspension.*

D. Damper Sizing

The fresh air damper is sized to handle the maximum flow of fresh air based on 1000 fpm (5 m/s) or 1 ft^2 (1 m^2) area per 1000 cfm

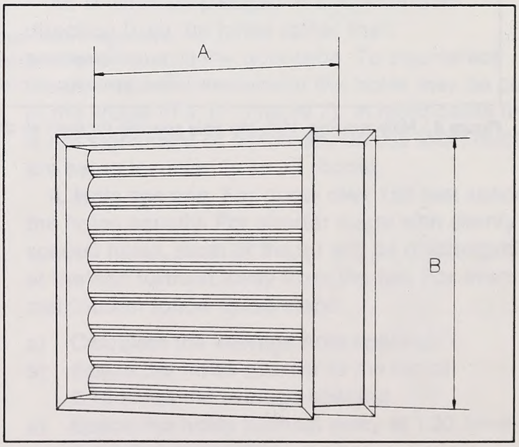


***Figure 12** - Air dampers. Air dampers control air flow from 0 to 100 per cent. Typical damper sizes and air flow capacities are shown in table 4.*

Table 4 - Air flow for various damper sizes

Height (in) - B*	Damper Width (in) - A* 12	18	24	30	36	42	48	54
12	1000	1500	2000	2500	3000	3500	4000	4500
18	1500	2300	3000	3800	4500	5300	6000	6800
24	2000	3000	4000	5000	6000	7000	8000	9000
30	2500	3800	5000	6300	7500	8800	10000	11300
36	3000	4500	6000	7500	9000	10500	12000	13500
42	3500	5300	7000	8800	10500	12300	14000	15800
48	4000	6000	8000	10000	12000	14000	16000	18000
54	4500	6800	9000	11300	13500	15800	18000	20300
60	5000	7500	10000	12500	15000	17500	20000	22500

Design air velocity is 1000 ft/min, based on gross opening area

Values shown are in cubic feet per minute (cfm)

Height (mm) - B*	Damper Width (mm) - A* 300	450	600	750	900	1050	1200	1350
300	500	700	900	1100	1400	1600	1800	2000
450	700	1000	1400	1700	2000	2400	2700	3000
600	900	1400	1800	2300	2700	3200	3600	4100
750	1100	1700	2300	2800	3400	3900	4500	5100
900	1400	2000	2700	3400	4100	4700	5400	6100
1050	1600	2400	3200	3900	4700	5500	6300	7100
1200	1800	2700	3600	4500	5400	6300	7200	8100
1350	2000	3000	4100	5100	6100	7100	8100	9100
1500	2300	3400	4500	5600	6800	7900	9000	10100

Design air velocity is 5 m/s, based on gross opening area.
Values shown are in litres per second (L/s)
* - Refer to Figure 12.

(5000 L/s) air flow. The recirculation damper is also sized based on an air velocity of 1000 fpm (5 m/s) flow of recirculated air. (Table 4) The following steps are followed:

1. Determine the maximum ventilation rate in cubic feet per minute and divide by 1000. This is the area in square feet of the fresh air damper. ((L/s) / 5000 = m^2 damper area)

2. Determine the minimum winter ventilation rate and subtract this from the maximum summer ventilation rate. Divide by 1000. This is the area in square feet of the recirculation damper and the cross-sectional area of the recirculation duct. ((L/s) / 5000 = m^2)

E. Air Exhaust

The air exhaust chimney should be insulated if it passes through a cold attic space. If it is not insulated, condensation will occur inside the chimney.

The size of chimney is based on the maximum airflow. Size on the basis of 1.5 ft^2 per 1000 cfm of airflow. (0.30 m^2 per 1000 L/s)

F. Supplemental Heat

Calculate the supplemental heat required at the January design temperature. A hot water heating system is ideal to use with positive pressure ventilation. Install unit heaters in the mixing room to supply the required heat. (Figure 6)

A room thermostat will control the unit heater and turn it to 'on' when the system is at its minimum ventilation rate and the room falls below the temperature set point.

G. Controls

The controls may be electric or pneumatic. The controls described here are electrical. (Figure 13) Controls are available from companies such as Honeywell, Johnson Controls, Barber-Colman and Penn.

For example, if Johnson controls are specified, order the Johnson control that replaces the Honeywell component.

1. Damper motor

The damper motor in this system is a proportional motor with a stroke of approximately 180 degrees. There is an option of ordering a spring return in case of power failure. The size of dampers influences the motor size required, however size could be quite variable depending on damper design (bearing type, parallel or opposed blades) and operating conditions (frost on blades, design pressure drop and air velocity). Motors are usually rated in terms of torque. Suggested sizes are:

Total Damper Blade Area ft^2	(m^2)	**Motor torque inch-pounds**
10-20	(1-2)	35
20-35	(2-3)	50
35-70	(3-6)	150

Examples of proportional motors providing 50 inch-pounds of torque are: Honeywell* M945, M955, M984.

These are 24 volt motors, therefore a transformer is required.

*For other brands ask for the model that replaces the Honeywell.

2. Proportional Controller

The option described here is a proportional remote bulb temperature control. The desired barn temperature should fall well within the set point range. For example a Honeywell T991A1526 has a set-point range of -18 to +38° C with a five foot copper capillary tube.

As the temperature changes, the fluid in the capillary bulb expands or contracts. This moves a 0-135 Ohm potentiometer in the controller. The motor has a feedback potentiometer and a balancing relay that electrically connects to the controller to form a bridge circuit. When the set

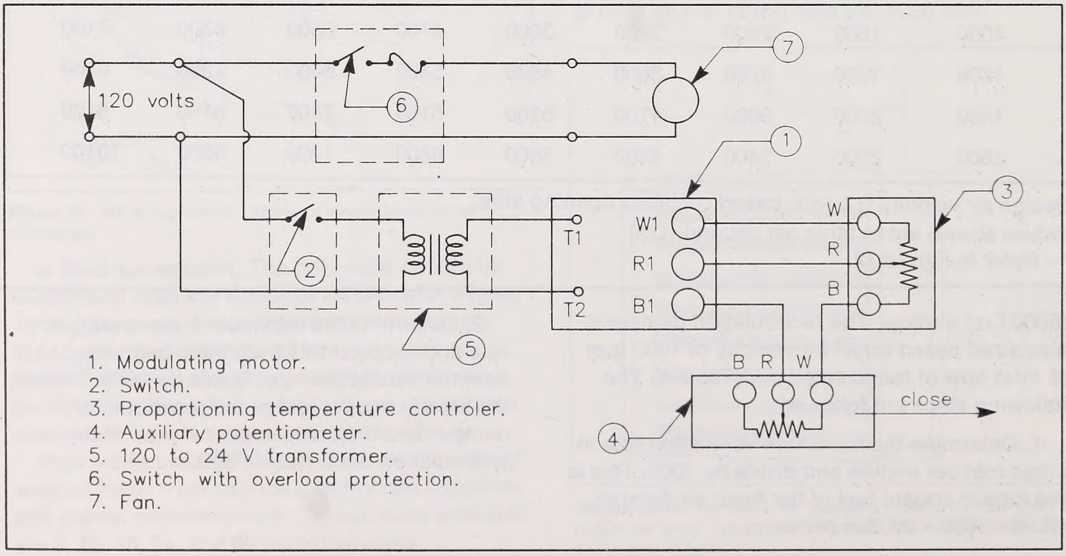

120 volts
⑦
⑥
①
③
T1
T2
W1
R1
B1
W
R
B
②
⑤
B R W
close
④
1. Modulating motor.
2. Switch.
3. Proportioning temperature controler.
4. Auxiliary potentiometer.
5. 120 to 24 V transformer.
6. Switch with overload protection.
7. Fan.

Figure 13 *- Wiring diagram for proportional control system. Honeywell controls are illustrated, equivalent controls may be chosen.*

point changes, the bridge is unbalanced and the motor then turns to balance the bridge. The motor stops in a position proportional to the resistance of the proportional controller.

3. Auxiliary Potentiometer

This is a 0-135 Ohm manual potentiometer that is connected in series with the controller and the motor. The purpose is to provide a manual minimum position adjustment of the damper motor. The resulting minimum damper position will provide sufficient fresh air to absorb moisture in the barn. This potentiometer should be labelled 'moisture control'. If the barn is filled to half capacity, the minimum damper position may be manually set to one-half the previous fresh air level.

4. Control Check-Out

- Set the auxiliary potentiometer to 'close'.
- Check the barn or ambient temperature.
- Set the controller above ambient temperature. The fresh air damper should close and the recirculation damper should open.
- Turn the auxiliary potentiometer to 'open'. The fresh air damper should open.
- Set the auxiliary potentiometer to 'close' and set the controller below ambient temperature. The fresh air damper should open and the recirculation damper should close.

If everything checks out, set the controller at the desired barn temperature and set the auxiliary potentiometer proportional to the desired minimum ventilation rate.

If the system does not check out, make sure that the wiring is correct. If the motor turns in the wrong direction, it should be physically turned around so that it is operating in the proper sequence.

H. Troubleshooting

1. The barn is wet, the air from the poly-tubes creates jets of fog. Fog and condensation occurs when cool, fresh air is introduced into a room that is excessively humid (80 to 100 per cent relative humidity). Warm air holds more moisture than cool air. If the air is saturated with moisture, then cooled with fresh air, some water has to condense.

The solution is to lower the humidity by opening the fresh air damper to admit more cool, dry air to absorb the water. Allow one hour to observe the effects of this adjustment. This procedure may lead to another problem. The extra cool air will cool the barn down. If this happens, supplemental heaters must be turned on.

2. The poly-tube is dripping water. Again, the humidity is too high. Follow the procedure for drying wet barns.

3. The dampers are freezing. It is likely that moist recirculation air is blowing against the fresh air damper. Install baffles to deflect the recirculation air or relocate the dampers so that warm air does not flow past the fresh air damper.

4. The poly-tube is not inflated properly. There may be too many holes in the poly-tube. A 240-volt fan may be wired to a 120-volt supply, thus running too slowly. There may be a tear in the poly-tube or the end may have come open.

5. The poly-tube is inflated too tightly, fan motors seem to burn out too quickly. Check the number of holes in the poly-tube. Too few holes restrict the fan. If there is a transition duct between the fan and poly-tube, check that it is not restricting the fan.

6. The barn seems to be under excessive positive pressure. Check the areas of the inlet dampers, recirculation dampers and exhaust chimney. Improper sizing may cause a pressure imbalance.

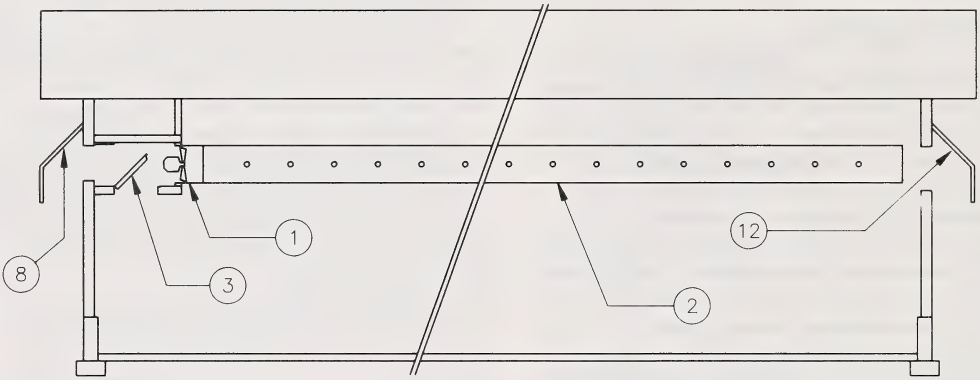
7. The poly-tube vibrates excessively. Ensure that the poly-tube is suspended in a straight line downstream from the fan. Eliminating holes from the poly-tube for the first two or three fan diameters is useful. A fan blade may be damaged or twisted.

Low-cost Alternatives

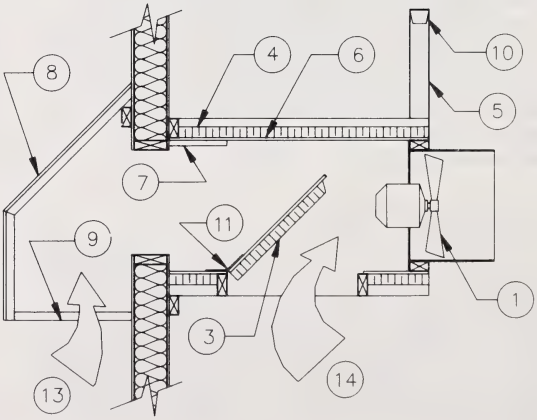
A complete system has thermostatically controlled air proportioning dampers to achieve a high degree of temperature control. There are however situations which do not require precise controls yet would benefit from the air blending and distribution features. This may include barns that are used only occasionally, or barns like beef cattle or sheep housing where a cold fresh air environment is all that is required. A simplified version of this air blending system is shown in Figure 14. It consists simply of an air intake fan and air distribution duct, with a manually adjusted air mixing baffle. For some situations, no duct is required. The mixing baffle is usually desired to regulate the amount of fresh air and/or moderate its temperature. Better ventilation is achieved by a continuous supply of a small amount of fresh air, than by occasional blasts of air.

The mixing baffle can be adjusted with a rope or lever system to give the desired temperature for the incoming air. Another variation of this intake mixing system is to extend the mixing box right to the floor to create a small room ahead of the distribution fan. Whichever approach is used depends on the type of building and livestock, and the needs of the operator.

For further information or assistance contact your Alberta Agriculture Regional Engineer.



1. Ventilation fan.
2. Air distribution — plastic tube or constructed duct (commercial tube and tube hanger system recommended).
3. Air proportioning damper — rigid foam insulation glued to plywood. Insulation to fit snugly betweenside walls. Use only recommended glue for specific foam types.
4. 2" rigid insulation or batts.
5. 2 x 4 framing throughout as shown. Frame and chamber sized to fit fan mounting requirements.
6. 3/8" plywood sheathing.
7. Distance from wall optional — top filler and and stop sized to suit. Damper could also be located at outside wall.
8. Outside air intake hood.
9. Bird screen.
10. Support with metal connector.
11. Control of baffle may be by a hinged rod to exterior crank arm (rod rotates in holes in side sheathing) or by light rope and pulley system. A damper motor and thermostat could be used.



12. Air outlet may be natural leakage, louvred wall vents, or eave vents.
13. Fresh air.
14. Return air.

Figure 14 *- Lost cost alternative.*

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